UNITED STATES DEPARTMENT OF COMMERCE
National Telecommunications and
Information Administration

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

Mr. Edmond J. Thomas
Chief
Office of Engineering and Technology
Federal Communications Commission
445 Twelfth Street S.W.
Washington, DC 20554

RE:
Review of Part 15 and Other Parts of the Commissions Rules, ET Docket 01-278

Dear Mr. Thomas:

On March 14, 2002, the National Telecommunications **and** Information Administration (NTIA), through its Office of Spectrum Management (OSM), provided initial comments in the above-referenced proceeding.[1] In those comments, **NTIA** requested additional time to document the results of a staff study with respect to field strength limits for radio frequency identification (RFID) tags in the 425-435 MHz band. NTIA has now completed its staff study and is hereby providing the following the results of the analysis for consideration by the Commission.

As summarized below and detailed in the attached technical analysis, NTIA believes that the Commission's proposals to permit operation of RFID tags in the 425-435 MHz band at increased power levels and increased duty factor raise serious interference issues for critical government radar systems that must operate in these frequencies. NTIA believes that the Commission's proposal to allow voice and data transmission under Section 15.231(a), will result in both an increased proliferation of devices and in transmission for a greater amount of time. These topics are discussed further below. Accordingly. **NTIA** does not support the Commission's proposals to allow voice and data transmissions under Section 15.231(a), and RFID operations under the proposed new section 15.240. Nevertheless, NTIA does view RFID tags as a promising, publicly beneficial technology. NTIA stands ready to assist the Commission in exploring other band options for this promising technology.

The analysis procedure used to determine the potential for interference between ground-based, airborne, and shipborne radars, and RFLD devices operating in the band 425-435 MHz **was** based on Recommendation ITU-R M.1461. The radar characteristics and protection criteria used in the analysis were obtained from Recommendation ITU-R M.1462. To determine the potential

[1] Letter from **Fredrick R. Wentland. Acting Associate Administrator** for **Spectrum Management, National Telecommunications and Information Administration to Edmond** J. Thomas, Chief, **Office** of **Engineering and Technology, Federal Communications Commission, (March 14, 2002), regarding Notice of Proposed Rule Making and Order, Review of Part 15 and other Parts of the Commission's Rules**, ET **Docket 01-278, FCC 01-290 (released** *Oct.* **15, 2001) (Part 15 NPRM).**

impact of individual WID interrogators and tags, the power received from an individual RFID device was computed and compared to the receiver noise at the radar IF output. **As** stated in the ITU-R M.1462, if the ratio of interfering signal to the receiver noise at the receiver's IF is greater than -6 dB, the resultant interference leads to a 6% reduction in detection range in the direction of the interference. The analysis did not consider the sum of all interfering sources per the ITU recommendation. Thus, the impact of multiple interference sources could be greater than predicted here.

The analysis (Enclosure 1) shows that in the case of airborne radar, the interference threshold is exceeded by as much as 35 dB at separation distances of 10km. In the case of ground based radars, the interference threshold is exceeded in the mainbeam and sidelobes to distances up to 30 km. In the case of shipborne radars, the criteria is exceed by as much as ***6*** dB to distances of 25 km. These levels of degradation to the radars in the band 425-435 MHz, which could be created by systems operating under this proposed rule change, are deemed to be unacceptable.

Section 15.231(a) - Proposed Changes Allowing Data & Voice Transmission above 70 MHz

In the Notice of Proposed Rule Making, the Commission proposes to remove the prohibition against voice, video, and data transmission contained in paragraph 15.231(a) of its Rules. In making this proposal, the Commission indicated its belief that elimination of this restriction would not **result** in an increased potential for interference noting "the lack of a record of interference complaints from devices operating under this section."[2] The Commission further concluded that the proposed change would not increase the potential for interference **as** long as the timing limits of paragraph 15.231(a) were retained.'

Although section 15.231 allows periodic operation in the band 40.66-40.70 MHz and at all frequencies above 70 MHz (except bands listed in section 15.205), historically remote control operations have been performed much more often in some bands, such **as** 307-315 and 390-434 MHz, than in others. The addition of data to systems that are currently used as control signals conflict with section 15.209 which sets limits for most Part 15 devices transmitting voice and data (at Least those that are not separately regulated such as unlicensed national information infrastructure (UNII) or ultrawideband (UWB)).

Section 15.231 of the Commission's Rules currently allows operation of control signals such **as** garage door openers, alarm systems, and remote switches. The Commission permits these operations at levels higher than the general section 15.209 limits, but requires that the operation be brief (i.e., a low duty factor), For example, at 430 MHz the general emissions limits of section 15.209 allow emissions of 200 microvolts/meter (μV/m), while paragraph 15.231(a) allows very low duty factor operations at levels of about 10,837 (μV/m). **As** currently written, paragraph 15.321(a) prohibits voice and data transmission. However, paragraph 15.231(e) currently allows voice and data. but at reduced field strengths (e.g., 4,300 μV/m is allowed at 430MHz). This restriction is based on the increased likelihood of interference resulting from more frequent transmissions associated with data communications as compared to the frequency

[2] **Part** 15 NPRM **at** ¶ 17.
[3] *Id.*

of transmission associated with control signals to open or close a garage door, or to lock or unlock a car. Even at the reduced field strength, the Cominission has restricted voice and data operations under paragraph 15.231(e) to a maximum duty factor of about 3.2 percent to minimize disruption of licensed services.

NTIA believes that it is likely that systems using voice and data transmissions would proliferate given the proposed changes to 15.231(a). The only timing restriction for non-periodic automatic operations under subparagraph 15.231(a)(2) is to turn off after 5 seconds. Thus, under the Commission's proposed rule change, a remote weather reporting station could automatically update a change in wind, temperature, or pressure each time either changes. Such a system would virtually be transmitting all the time. Similarly, a conventional push-to-talk walkie-talkie could now operate under 15.231(a).

Increased Field Strength and Duty Factor of Use of RFID Tags in the Band 425-435 MHz (Proposed Section 15.240)

In the NPRM, *the* Commission proposes to allow the operation of RFID systems in *the* 425-435 MHz band. The Commission would limit maximum field strength to 110,000 microvolts per meter measured at a distance of 3 meters, and in general, limit transmissions to 120 seconds with at least a 10 second silent period between transmissions.[4]

The 420-450 MHz band is the only radiolocation band available that offers propagation characteristics essential to longer-range tracking and foliage penetration.[5] The Government systems in this band are essential to the nation's early warning defense capability, and tracking of objects in space. Given the importance of these systems to our national defense, NTIA and Department of Defense have performed analyses to determine the potential impact of the Commission's proposed rule changes to allow greater power, duration, or duty factor of transmissions from RFID tags in the 425-435 MHz portion of the band. Enclosure 1 indicates that potential exists for radar performance degradation, even from a single RFID emitter at large separation distances, The analysis also shows that the Commission's proposal to permit increased duty factors and field strengths would result in received power levels in excess of the required interference-to-noise ratio, thus causing desensitization, range reduction, and loss of targets. Since the Commission allows RFID tags to operate on an unlicensed basis, it would be virtually impossible to prevent these devices from operating within areas close to Government radar operations given the combination of mobile radar operations and the unrestricted nature of Part 15 operations. This problem could be exacerbated by the fact that different types of RFID systems may operate in one geographic area on different frequencies creating significant signal density over a 10 MHz portion of the band.

[4] *Id.* at 27.
[5] **Recommendation ITU-R P.833**

NTIA Position

NTIA has grave concerns about the Commission's proposal to amend its Part 15 rules to permit the operation of RFID tags in the band 425-435 MHz at increased power levels and increased duty factor (or activity factor) and data transmission by remote control devices. Given the likelihood of interference to critical government radars, NTIA is unable to support the Commissions proposal.

As noted above, NTIA recognizes that RFID tags have the potential to be a publicly beneficial technology, particularly with respect to national security applications. NTIA accordingly urges the Commission to explore other bands that might be able to accommodate the technology with out causing unacceptable interference to critical incumbent users. The function of container tag systems might be accommodated in a manner similar to land mobile radio because of the mobile nature of tag systems. A band such as 450-470 MHz would provide similar propagation characteristics to those of the currently proposed band and would reduce the potential for mutual confliction that would result from operations in the same band as high power radars. It is recognized that this band is also important nationally since it is used by non-Federal systems for police, fire and rescue and other commercial services and would require some reassignments on a national basis. The band 902-928 MHz might also accommodate this service under spread spectrum operation. *Also,* for worldwide operations, the band 2400-2483.5 MHz might accommodate this service under spread spectrum operations.

NTIA stands ready to continue to work with the Commission on this rulemaking, particularly with respect to exploring other potential options for deploying promising RFID technology. If you have any questions regarding this subject, please call me at (202) 482-1850, or William Doolan, in OSM's System Review Branch at (202) 482-2320.

Respectfully,

Fredrick R. Wentland
Acting Associate Administrator
Office of Spectrum Management

Enclosure

Enclosure 1

ANALYSIS OF RFID TAGS IN THE 425-435 MHz BAND

1. Introduction

This analysis addresses the potential impact of the changes proposed in paragraphs 25-27 of the Notice of Proposed Rule Making in ET Docket 01-278, which would allow increased field strength and duty factor for unlicensed radio frequency identification (RFID) data transmissions in the frequency range 425-435 MHz. Nationally, the frequency band 420-450 MHz is allocated on a primary basis to Government radiolocation limited to the military services by Footnote G2. However, internationally, the bands 420-430 and 440-450 MHz, are allocated to the fixed and mobile services on a primary basis, and to the radiolocation service on a secondary basis.

Federal government systems in this band include long-range radars, and telemetry and telecommand. The radars include ground, shipbome, and airborne long-range surveillance systems essential to the Nation's aerospace early warning, missile warning, fire-control defense capabilities, and tracking of exo-atmospheric and space objects. Radar systems that operate in the band 420-450 MHz are critical to homeland security. This band is also important because it is the only available radiolocation band for the detection of advanced technology systems and low observables. The propagation characteristics of the band 425-435 MHz are also critical because of the foliage penetration properties as compared to other frequency bands above 1 GHz (See Recommendation ITU-R P.833). Given the proliferation of unlicensed systems in the 902-928 MHz radiolocation band, radiolocation operations in the band 420-450 MHz have become very important.

2. Summary of Proposed Changes to Part 15

The Commission has proposed to permit the operations of unlicensed devices for location identification and exchange of data under a new section, 15.240. Currently, RFID tags operate at under sections 15.231(a)/(b) & 15.231(e). Table 1 summarizes the current rule changes proposed by the Commission.

2.1 Increased Field Strength in the Band 425-435 MHz

Currently, data transmissions are only permitted under section 15.231(e) which is limited to an average field strength of 4400 µV/m and peak field strength of 44,000 µV/m at 3 meters. For data exchange, the NPRM proposes, in the new section 15.240, to change the average field strength limit to 11,000 µV/m and the peak field strength limit to 110,000µV/m as measured at three meters. At 433 MHz, the proposed increase is about 8 dB above the current level for intermittent transmissions of data.

2.2 Increased Duty Factor in the Band 425-435 MHz

The NPRM also proposes to increase the allowable "on-time" or duty factor of operation of RFID tags in this band, from one second over a two-minute period, to operating continuously for up to two minutes, and then turning off for 10 seconds (Unless the data received is questionable, in which case the entire sequence of up to two minutes could be repeated). This proposal would increase the allowable duty cycle from 3.2 percent to greater than 92 percent with commensurate increased potential for interference. Under the proposed regulation, if the data received is questionable, the entire sequence of up to two minutes to be repeated without the 10-second off time, and raises the duty cycle of the RFID device to 96%. This increase in duty factor is the main concern since the RFID tag signals will appear as a continuous noise-like signal. In general, radars can mitigate interference through signal processing if the duty factor of the undesired signal is only a few percent (See Recommendation ITU-R M.1372).

Table 1. Current Part 15.231 and Proposed New Part 15.240 Comparison

Section ⇒	15.231(a)/(b)	15.231(e)	15.240 (New)
1. Applications	Control Signal/ Recognition Codes	Any Application (including data transfer)	Location, Identification, and Data Exchange
2. Data Allowed ?	No/Yes*	Yes	Yes
3. Voice Allowed ?	No/ Yes*	Yes	No
4. Average field strength in any .1 sec interval @ 430 MHz	11,000 µV/m	4,400 µV/m	11,000 µV/m
5. Peak field strength (may use quasi peak detector to measure) @ 430 MHz	110,000 µV/m	44,000 µV/m	110,000 µV/m
6. Minimum off time	1 hour	30 sec	10 sec (0 sec if retransmission is necessary)
7. Non-Periodic on time	5 sec	1 sec	120 sec
8. Periodic operations	$D_c < 0.14\%$ security safety	$D_c < 3.2\%$	$D_c < 92\%$ (<96% for retransmissions)
9. Frequency	> 70 MHz	> 70 MHz	425-435 MHz

* Existing rules/proposed rule

3. Analysis

The procedure for determining the potential for interference between radars and RFID devices operating in the band 425-435 MHz was based on Recommendation ITU-R M.1461. The radar characteristics and protection criteria used in this analysis were obtained from Recommendation ITU-R M.1462.

To determine the potential impact of individual RFID interrogators and tags, it is necessary to compute the power received from an individual device and compare it to the receiver noise at the radar IF output. As stated in the ITU-R recommendation, if the ratio of interfering signal to the receiver noise at the receiver's IF is greater than -6 dB, the resultant interference leads to a 6% reduction in detection range in the direction of the interference. The noise increase should be considered for the sum of all interfering sources per the ITU recommendation. However, this paper treats only the interference from a single source. Thus, the impact of multiple interference sources would be greater than predicted here.

3.1 Airborne Radar Analysis

For the analysis of interference to airborne radar, the characteristics of airborne radar are taken from Table 3 of Rec. ITU-R M.1462 and listed below.

Antenna elevation beam scan: 60^{o}
Antenna gain: 22 dB
Noise figure: 5 dB
Receiver IF Bandwidth: 1 MHz
Receiver Noise Power: -109 dBm (kTB for 1 MHz bandwidth and 5 dB noise figure)
Aircraft Ceiling Altitude: 9 km (slant range 10.4 km for -60^{o} antenna elevation angle)
Frequency: 435 MHz
Interference Criteria: I/N = -6 dB
Receiver Losses: ≈ 2 dB (Not specified in Rec. ITU-R M1462 - estimated)

In order to compute the received power from the RFID tag device, it is necessary to first compute the equivalent isotropic radiated power (EIRP) of the RFID device.

Equation 1 was used to determine the EIRP of an RFID transmitter required to produce a field strength of 110,000 μV/m at 3 meters, in free space.

$$\text{EIRP (dBm)} = E_o\,(\text{dB V/m}) + 20\log(d) - 104.8 \quad (1)$$

[6]

Where:
d is the distance in meters from the transmitter at which the field strength is measured.

From Equation 1, the EIRP is 5.6 dBm.

In order to compute the power received from an individual RFID tag transmitter to compare it to the receiver noise of the radar, Equation 2 is used. Since the duty cycle/on time, or activity factor of the device may be quite high, the peak field strength is used in this case. The Commission's NPRM also did not propose any restrictions on, or the details or limitations of the modulation to be permitted for RFID tag systems.

[6] NTIA Special Publication 01-43 at p.2-2.

Using Equation **2 as** shown below, the received power from **an** individual **RFID** tag **is** calculated,

$$P_R = EIRP - L_p + G_R - L_R \quad (2)$$

Where:

EIRP = equivalent Isotropically radiated power from RFID tag, in dBm
= 5.6 dBm

G_R = the victim receiver mainbeam antenna gain, in dBi

L_p = the propagation **loss** (free-space since this case is line **of** sight) between transmitting and receiving antennas, in dB. The distance separation (10.4 km) is the slant range determined from the maximum altitude of the aircraft (9 km) with an antenna depression angle of 60 degrees from horizontal (L_p = 105.6 dB).

L_R = receiver losses (2 dB estimated)

$$\begin{aligned} P_R &= EIRP - L_p + G_R - L_R \\ &= 5.6\text{ dBm} - 105.6\text{ dB} + 22\text{ dBi} - 2\text{ dB} \\ &= -80\text{ dBm} \end{aligned}$$

With a system noise power of -109 dBm and a required I/N of less than -6 dB, the received power level is greater than -115 dBm and exceeds **the** established protection criteria by **35** dB.

3.2 Shipborne Radar Analysis

An analysis of the potential interference from **RFID** devices to shipborne radars using the previous technique follows:

The characteristics for shipborne radar have been taken from Table **4** of ITU-R Recommendation **M.1462** and are listed below.

Antenna gain: 30 dBi
Bandwidth: 2 MHz (kTB = -111 dBm)
Noise figure: 5 dB
Receiver Noise Power: -106 dBm
Frequency: **435** MHz
Interference Criteria: I/N = - 6 dB
Receiver Losses: ≈ 2 dB (estimated)

Using the protection criteria of ITU-R Rec. M.1462, signals greater than **-112** dBm **(I/N= *-6*)** will exceed the interference criteria of shipborne radars with similar characteristics.

In order to determine the potential effects of RFID tags ***to*** shipborne radars, a distance of 25 km is assumed **from** the ship **to** shore. For antenna heights of 8 meters for the RFID tag (12-foot high containers stacked two high), and a radar antenna height of 21 meters **(70** feet), the radio horizon **would** be approximately 31 km and the distance used is within line-of-sight.

Solving Equation 2 for L_p:

P_R = EIRP B L_p + G_R - L_R
L_p = EIRP B P_R + G_R - L_R
L_p = 146 dB (required loss)

Using the NTIA's Irregular Terrain Model (with the appropriate ground constants for propagation over seawater), the propagation loss at 25 km is only 134 dB and exceeds the interference threshold of -112 dBm by 12 dB. Using free-space loss in this case would only yield a loss of 113 dB.

With a system receiver noise of -106 dBm and a required I/N of less than -6 dB, received power levels greater than -112 dBm will exceed the interference criteria. In this case, the resultant I/N is +6 dB at 25 km. This is 12 dB in excess of the interference criteria. Shorter ranges would cause higher I/N values. Furthermore, in this analysis, no attempt has been made to estimate the potential interference from an aggregate of multiple RFID devices. Multiple RFID devices will increase the potential for interference.

3.3 Ground-based Radar Analysis

The characteristics for ground-based radar have been taken from Table 4 of ITU-R Recommendation M.1462 and are listed below.

Antenna Gain: 38.5 dBi (planar array)
Antenna Scan: 3-85° elevation, 240° azimuth
Antenna Beamwidth: 2.2° elevation, 2.2° azimuth
Receiver Noise Temperature: 450° K (F_n = 4.1 dB)
Bandwidth: 1 or 5 MHz (selectable)
KTB = -114 dBm, (for 1 MHz BW @ 290° K)
Receiver Noise Power: -110 dBm
Interference criteria I/N = -6 dB
Frequency: 435 MHz
Receiver Losses: = 2 dB (estimated)

Given the sensitivity of the radar systems and using the recommended protection criteria of ITU-R M.1462 (I/N= -6), received signals greater than -116 dBm exceed the criteria (interference threshold I_{Max} = -116 dBm). Computing the required separation distance using free-space loss results in an erroneous required separation distance of over 1600 km. A more appropriate and simpler approach is to first compute the radio horizon of the two systems based on their antenna heights, determine if interference is predicted, and proceed with the analysis depending on the result.

For an WID antenna height of 8 meters (12-foot high containers stacked two high), and a ground-based-antennaheight of 20 meters (65 6 feet), the radio horizon would be approximately 30 km (18.6 miles).

The received signal level from a RFID emitter with an EIRP of 5.6 dBm at a distance of 29.5 km is compared to the interference threshold of -116 dBm.

$$P_R = EIRP - L_p + G_R - L_R$$

Where:

L_p = 129 dB using the ITM (Free space loss = 114.6 dB)

$$P_R = EIRP - L_p + G_R - L_R$$
$$= 5.6 - 129 + 38.5 - 2$$
$$= -86.9 \text{ dBm}$$

Comparing the received signal level of –86.9 dBm to the interference threshold of -116 dBm, the criterion is exceeded by more than 29 dB in the mainbeam. Given the beam shape and geometly of the scenario, and assuming that the first sidelobe is about 30 dB less than the mainbeam gain, a minimum separation distance of about 30 km is required to achieve the interference threshold. At shorter distance separations, the interference threshold will be exceeded. Furthermore, in this analysis, no attempt has been made to estimate the potential interference from an aggregate of multiple RFID devices. Multiple RFID devices will increase the potential for interference.

4. Summary

The analysis shows that the potential exists for radar performance degradation due to the proposed increased field strengths from a single RFID emitter at relatively large separation distances. The interference potential is even greater when considering that the proposal makes no distinction between data and control signals. With the unlicensed nature of the RFID service, it would be very difficult to prevent these devices from operating in the vicinity of radar systems. There would also be no way to maintain a required separation distance since most of the radars in this band are mobile. Given the request for systems to operate over 10 MHz of spectrum, there could potentially be RFID systems on different frequencies. Unlicensed use is likely to result in many applications of this technology, further increasing the likelihood that one of more will operate in the vicinity of a radar. The levels of degradation to the radars in the band 425-435 MHz that could be created by systems operating under this proposed rule change are deemed to be unacceptable.